Original Article

A Comparison Between Measured Maxillopharyngeal Angle On Lateral Cervical Radiograph With Modified Mallampati Classification In Predicting Difficult Larnygoscopy: A Blinded Interventional Study

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ABSTRACT

Background: Existing techniques of predicting difficult laryngoscopy are inadequate requiring evaluation of Maxillopharyngeal Angle (MP-A) on lateral cervical radiograph described. **Objectives:** This study aimed to compare MP-A test with Modified Mallapati Test (MMT) in predicting their diagnostic values and Area Under Curve of Receiver Operating Characteristic Curve (AUCROCC) of both test. **Methods:** This is a double blinded interventional study of 93 patients. Each patient's MMT score was assessed during preoperative assessment and subsequent MP-A test done by obtaining lateral cervical radiograph with the head in neutral position. Laryngeal view was assessed using Cormack-Lehane grade after induction of anesthesia, was used as reference standard to determine the diagnostic values of MMT and MP-A respectively. **Results:** The MP-A compared to MMT in predicting difficult larngoscopy had higher sensitivity (77.78 vs 44.44) specificity (88.10 vs 67.86) and accuracy (87.10 vs 65.59) with higher Odd Ratio(26.12 vs 1.68). The AUCROCC was significantly higher in MP-A test 0.83(95%CI: 0.67, 0.99) (P = 0.001) vs MMT 0.56(95%CI: 0.36, 0.76) (P = 0.546) with LR+ of 6.53 vs 1.38. **Conclusion:** The Maxillopharyngeal Angle test was superior in predicting difficult laryngoscopy as compared to Modified Mallampati Test.

Keywords: maxillopharyngeal angle, Modified Mallampati, difficult laryngoscopy, lateral cervical radiograph, difficult intubation

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INTRODUCTION

Maintaining of the airway following induction of general anaesthesia has always been a great concern and responsibility of anaesthesiologist. Inability of managing difficult airway has contributed to approximately 40% of anaesthesiology related death (1). Various airway assessment methods have been employed to predict incidence of difficult laryngoscopy and intubation. Mallampati (2) developed a grading system that assesses the height of the mouth, the distance from the tongue to the roof of the mouth and therefore the amount of space within the oral cavity available for laryngoscopy. Modified Mallampati Test (MMT) has been widely studied and was found to have relatively high specificity but low sensitivity with high number of false positive result(3). Thus, unanticipated difficult intubation continue to become a major problem regardless proper airway assessment performed. Other bedside predictor tests also have limited reliability and poor sensitivity due to inter-assessor variability.

Objective predictor test by assessment of maxillopharyngeal angle (MP-A) is free from inter-observer subjective variation and was proposed as a simple, reproducible and noninvasive method to predict difficult laryngoscopy preoperatively. The MP-A term was first coined in assessing tracheal intubation among children suffering from congenital craniofacial anomalies (4). Subquently, lateral cervical radiograph with MP-A of less than 90° with other normal craniofacial parameters was quoted to predict difficult laryngoscopy (5). Gupta K *et. al*.(6) performed the first study to evaluate MP-A in predicting difficult larngoscopy and found correlation between degrees of this angle with levels of difficult laryngoscopy.

This study aimed at comparing effectiveness of MP-A technique in comparison to MMT in predicting difficult laryngoscopy by providing impartial statistical values.

METHODS

Following approval from the ethical committee (USMKK/PPSP/JEPeM/271.3.(7)) and written consent from the patients, consecutive patients with ASA I and II scheduled for elective surgery under general anaesthesia, aged 18 to 65 years between February to June 2014 were randomized using simple random sampling and evaluated for enrollment. The patient with Body Mass Index(BMI) > 35 kg/m^2, pregnant or patient with increased risk of aspiration, those for Rapid Sequence Induction (RSI) or requiring awake intubation were excluded from the study. On top of that, the patients with preexisting neck, facial and upper airway distortion and limitation were also excluded.

The single proportion formula was used to calculate the sample size with reference to sensitivity and specificity of maxilla-pharyngeal angle (MP-A) as a 10% clinically important difference(3) (α;0.05 Zα; 1.96 Δ; 0.1) with dropped out of 10% resulting in sample size of 106 patients.

Preoperatively, anaesthetist with more than 2 years of experience was blinded to the X-Ray findings and assessed the Mallampathi Score using Modified Mallampathi Test (MMT) and radiographers were instructed to obtain the appropriate lateral cervical radiograph of each patient for measurement of MP-A. Classification of MMT is based on oropharyngeal view with the patient sitting and tongue fully protruded as below: class I = visualization of soft palate, uvula,tonsillar pillar; class II = visualization of soft palate, and uvula only; class III = visualization of soft palate; class IV = no other pharyngeal structure except hard palate seen (2, 7). MMT grade I and II is categorized under easy predicted laryngoscopy while grade II and IV is categorized as difficult predicted laryngoscopy.

In order to get the MP-A, the radiographs were taken at the end of expiration when the head was in a neutral position by aligning the patients' tragus with midaxillary line and the patient was instructed to look at a fixed target located parallel to the eye level (8). The patients were also instructed to close the jaw in neutral occlusive position and to breathe quietly. The designated radiographer measure the MP-A in the hospital's x-ray database i.e; PAC-IV system. The class of MP-A is as follows: class I = >110° class II = 110-90° class III < 90° and class IV = < 85° (Figure 1). Class I and II was predicted to have easy outcome while class III and IV were predicted to be difficult. In order to assure the standardization of the measurements, two radiographers with more than 5 years' experience were assigned to measure the MP-A in the X-ray database and the mean MP-A values will be taken if any discrepancy happened.

The patient was preoxygenated with 100 % oxygen for 5 minutes and induced with IV fentanyl 2 µ/kg, IV propofol 2-3 mg/kg and IV rocuronium of 0.6 mg/kg at induction of anaesthesia. A single anaesthetist who has more than 5 year's experience and blinded to the MMT and MP-A classes,was appointed to assess the difficulty of laryngoscopy at intubation (Cormack Lehane Classification). The patient's head was placed in the sniffing position, and laryngoscopy was performed with Macintosh size 3 blade (Welch Allyn Inc., Skaneatills Falls, NY) without applying external laryngeal pressure while reporting the laryngeal view. If difficult laryngoscopy was encountered, the patient was managed according to the Difficult Airway Algorithm based on the Diffficult Airway Society guidelines (9).

The laryngeal view upon intubation which was a reference standard assessment of difficult intubation as graded by Cormack and Lehane (10) classification as follow: grade I (full view of glottis and vocal cord) grade II (glottis partly seen) grade III (only the epiglottis seen) or grade IV (epiglottis not seen). A grade I and II was categorized under easy intubation while grade III and IV categorized under difficult intubation.

The Statistical Package for the Social Science (SPSS ver. 22) software was used to assess the preoperative data and laryngoscopy findings. Descriptive statistic was used for the demographic data and diagnostic values were obtained for each of the studied predictive

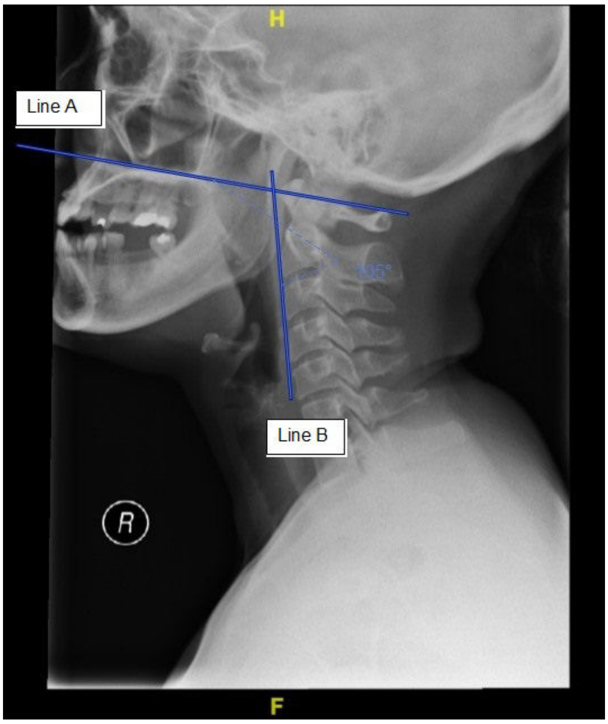

Figure 1. Radiograph of Maxillo-pharyngeal Angle (MP-A) on lateral cervical X- ray

Table 1. Association of Demographic Factor the Patients and Odds of Difficult Laryngoscopy using Simple Logistic Regression (n=93)

Patient characteristics	b	Crude OR (95% CI)	Wald Statistic (dF)	P value^
Age (years)	-0.01	0.99 (0.94, 1.04)	0.15 (1)	0.692
Gender				
Male	0.00	1		
Female	1.11	3.03 (0.60,15.47)	1.78 (1)	0.182
Body Mass Index (kg/m^2)	0.29	1.33 (1.05, 1.70)	5.45 (1)	0.020

Table 2. Comparison Between the Result of Two Predictive Test and Ease of Intubation at Laryngoscopy

Predictive test	Ease of Intubation (%)*	
	Easy	Difficult
Modified Mallampati test (MMT)		
Easy	57 (61.3)	5 (5.4)
Difficult	27 (29.0)	4 (4.3)
Maxiilopharngeal Angle (MP-A) test		
Easy	74 (79.6)	2 (2.2)
difficult	10 (10.6)	7 (7.6)

*based on Cormack Lehane Grading (n = 93)

Table 3. Statistical Values of Modified Mallampati Test and Maxillopharyngeal Angle as Predictive Test

Predictive test	Acc % (95% CI)	Se % (95% CI)	Sp % (95% CI)	PPV % (95% CI)	NPV % (95% CI)
Modified Mallampati Test (MMT)*	65.59 (61.33, 70.21)	44.44 (41.35, 48.77)	67.86 (62.82, 71.47)	12.90 (7.17, 21.13)	91.94 (88.37, 93.62)
Maxillopharyngeal Angle Test (MP-A)**	87.10 (84.37, 90.13)	77.78 (72.45, 80.44)	88.10 (83.16, 92.11)	41.18 (32.75, 50.67)	97.37 (94.68, 99.10)

* Odd Ratio (OR)= 1.68 ** Odd Ratio (OR) = 26.12 Acc = accuracy Se = sensitivity Sp = Specificity PPV = Positive Predictive Value NPV = Negative Predictive Value

Table 4: Reciever Operating Characteristic (ROC) curve for Modified Mallampati Score and Maxillopharyngeal Angle as Predictive Test.

Predictive test	AUC (95% CI)	p-value
Modified Mallampati Test	0.56 (0.36, 0.76)	0.546
Maxillopharyngeal Angle Test	0.83 (0.67, 0.99)	0.001

test. These included sensitivity, specificity, accuracy and positive and negative predictive values. The area under curve (AUC) which corresponded to the receiver operating characteristic (ROC) of each predicted tests were assessed.

RESULTS

Out of 106 patient recruited, a total of 13 patients were dropped out from the study, 10 were due to deferred surgery for optimization, changed of anaesthetic plan (intubation to Laryngeal Mask Airway(LMA), and changed of surgical plan from elective to emergency operation at preoperative stage. Three of the patients were excluded at laryngoscopy due to inadequate anaesthesia manifested by coughing and movement at laryngoscopy. Based on Table 1, the mean age was 32.3(SD=13.77) years and the Body Mass Index(BMI) was 26.9(SD=3.52) kg/m ^{2}. We found for every 1kg/m^2 increase of BMI, there was 1.33 times increase in the odds of having difficult laryngoscopy (P = 0.020) but none of the patients characteristics were found to increase or decrease the classes of MP-A when simple logistic regression was performed (*P*=0.312). There were 62 patients with MMT class I and II and 31 patients with MMT class III and IV. On the other hand, there were 76 patients with MP-A class I and II and 17 of them with MP-A class III and IV (Table 2). The prevalence of predicted difficult laryngoscopy of the patient assessed using MMT was 9.86% with Positive Likelihood Ratio (LR+) of 1.38 and Negative Likelihood Ratio(LR-) of 0.82. In contrast, the prevalence for MP-A assessment was 9.68% with LR+ of 6.53 and LR- of 0.25 (Table 3). The receiver operating characteristic (ROC) and its corresponding area under curve (AUC) of each predictive tests is showed excellent diagnostic performance provided by Maxillopharyngeal angle technique i.e; 0.83 (95% CI: 0.67, 0.99) vs. Modified Mallampati Test 0.56 (95% CI: 0.36, 0.76) (Table 4). We encountered 9 (9.68%) patients with difficult laryngoscopy and 6(6.45%) was successfully intubated with optimizing maneuver, 2 (2.15%) with Bougie and 1 (1.08%) with video laryngoscope (C-MAC).

DISCUSSION

Unanticipated difficult intubation with difficulty to maintain ventilation is one of the main factors contributing to significant morbidity and mortality in patients undergoing general anaesthesia. Although the incidence of difficult intubation was less than 0.35%, various bedside assessments were introduced to predict difficult intubation (3, 11). We encountered 9.68% incidence of difficult intubation but all of them were successfully intubated. Prakash *et. al.* (12) reported incidence of difficult intubation is 9.70% while other study concluded that 75% of patients with difficult laryngoscopy will end up with difficult intubation(13) . Various author reported increases risk of difficult intubation in obese patients(3, 14) but in contrast to other study, increasing age was not the factor associated with increased risk of difficult intubation. Moon *et. al.*(15) reported cervical rigidity and reduction of thyromental distance and interincisor gap contributed to difficult intubation in middle age and elderly patients. Wilson *et. al.*(16) identified several important factors contributing to difficult intubation including weight, head and neck movement, jaw movement, receding mandible and buck teeth. Many of current assessments accommodates described factors including introduction of Savva and Patel's distance and Upper Lip Bite Test(17, 18)

In a single study or metaanalysis, predictive test can be considered diagnostically conclusive when the positive likelihood ratio (LR+) is more than 10 or when the area under curve (AUC) of its summary receiver operating characteristic (sROC) is more than 0.75 (metaanalysis) (19, 20). A test with LR+ of 5 to 10 is diagnostically accurate with moderately conclusive increase in the likelihood of the predicted outcome. In addition, a predictive test is classically regarded as good when its AUC of its ROC curve (AUCROCC) is more than 0.8 and excellent when it reaches 0.9. When AUCROCC is near the 0.5 diagonal line, the test worthlessly predicts the correct outcome only half of the time. Thus, MMT is a poor clinical predictor for difficult laryngoscopy as evidenced by the poor diagnostic performance (AUCROCC = 0.56), and poor LR+, sensitivity, specificity, PPV and NPV. These results were parallel to previously conducted studies. L.H Lundstrom *et. al* (21) and Shiga *et. al.*(3) demonstrated that the MMT was inadequate as a stand-alone test for difficult laryngoscopy and intubation, although it may well be a part of multivariate model for prediction of difficult intubation and has a marginal diagnostic value. Another study reported that MMT has limited accuracy for predicting difficult airway and thus is not a useful screening test (22). MMT is widely used as predictive test since it measures the size of the tongue relative to oral cavity and detects sufficiency of mouth opening to allow laryngeal view. Despite of this theoretical advantage, MMT failed to demonstrate superior and reliable diagnostic value. It was suggested that MMT is better at predicting difficult laryngoscopy associated with soft tissue changes when compared to other anatomical factors thus benefited obstetric and obese population. Better accuracy of MMT is expected if these particular patients are included in the study. Moreover, MMT is assessor dependent and prediction of difficult laryngoscopy has poor to moderate inter-assessor reliability (23).

In contrast, the MP-A technique appears to be promising as a good diagnostic performance. Its AUCROCC covered nearly 83% of the graph. In addition, LR+ was 6.53 making it a diagnostically accurate test. The MP-A test has 26 times the odds of correct prediction as compared to false prediction and has 87% accuracy. The higher PPV in this test signifies that the positive test from this technique (MP-A of < 90◦) is more predictive of difficult laryngoscopy than a positive MMT classification (Class II and IV) does. Similarly, higher NPV indicates a negative MP-A test rule out difficult laryngoscopy more readily than a negative MMT score. The original study by Gupta et. al. (6) assessed the correlation between parameters including the MP-A, MMT, atlanto-occipital extension and thyromental distance. The authors reported that visualization of the larynx upon direct laryngoscopy was impossible when the MP-A is less than 90°. MP-A is closely related with the extension of the neck at the atlantooccipital joint where restriction of neck extension is associated with difficult laryngoscopy. The limit of neck extension in airway evaluation is classically assessed by looking at the movement of the head and quantifying the extent of movement based on certain thresholds, by measuring the angle of neck extension with a protractor or measuring the sternomental or thyromental distances(17). These measurements might not accurately reflect difficult laryngoscopy as they are dynamic and influenced by various factors including pain and anaesthesia with inter-assessor variability.

Nevertheless, MP-A test employs a static value that measures mobility of the head and neck during laryngoscopy and independent to pain and anaesthesia. The angle varies among patients without craniofacial abnormality and cervical spine disease making it a suitable test for patients without structural limitation that may render laryngoscopy difficult. The obtained value is accurate and not influenced by inter-assessor variability and can be easily retrieved for re-examination. Moreover, the radiograph can be used for measurement of mandibulohyoid distance, atlanto-occipital gap, C1-C2 gap, as well as anterior and posterior mandibular length. However, MP-A technique exposes the patients to radiation of 0.2mSV, involves additional cost and not a bedside test.

CONCLUSION

In conclusion, the MP-A technique has better diagnostic values as compared to MMT classification in predicting difficult laryngoscopy. MP-A technique has significantly higher AUCROCC, higher odd ratio, sensitivity, specificity and accuracy with lower false positive and negative rates and improve prediction of difficult laryngoscopy in the patient for elective intubation with higher risk on clinical assessment.

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REFERENCES

1. Cheney FW. The American Society of Anesthesiologists Closed Claims Project What Have We Learned, How Has It Affected Practice, and How Will It Affect Practice in the Future? The Journal of the American Society of Anesthesiologists. 1999;91(2):552-6.
2. Mallampati SR. Clinical sign to predict difficult tracheal intubation (hypothesis). Canadian Journal of Anesthesia/Journal canadien d'anesthésie. 1983;30(3):316-7.
3. Shiga T, Wajima Zi, Inoue T, Sakamoto A. Predicting Difficult Intubation in Apparently Normal PatientsA Meta-analysis of Bedside Screening Test Performance. The Journal of the American Society of Anesthesiologists. 2005;103(2):429-37.
4. Delegue L, Rosenberg S, Ghnassia M, Manlot G, Guilbert M. [The tracheal intubation of children suffering from congenital cranio-facial anomalies. Pre-operative anticipation of its technical problems (author's transl)]. Anesthesie, analgesie, reanimation. 1979;37(3-4):133-8.(abstract)
5. Hatch D. Airway management in cleft lip and palate surgery. British journal of anaesthesia. 1996;76(6):755-6.
6. Gupta K, Gupta PK. Assessment of difficult laryngoscopy by electronically measured maxillo-pharyngeal angle on lateral cervical radiograph: A prospective study. Saudi journal of anaesthesia. 2010;4(3):158.
7. Mallampati SR, Gatt SP, Gugino LD, Desai SP, Waraksa B, Freiberger D, et al. A clinical sign to predict difficult tracheal intubation; a prospective study. Canadian Anaesthetists' Society Journal. 1985;32(4):429-34.
8. Schriger DL, Larmon B, LeGassick T, Blinman T. Spinal immobilization on a flat backboard: does it result in neutral position of the cervical spine? Annals of emergency medicine. 1991;20(8):878-81.
9. Henderson J, Popat M, Latto I, Pearce A. Difficult Airway Society guidelines for management of the unanticipated difficult intubation. Anaesthesia. 2004;59(7):675-94.
10. Cormack R, Lehane J. Difficult tracheal intubation in obstetrics. Anaesthesia. 1984;39(11):1105-11.
11. Tse J, Rimm E, Hussain A. Predicting difficult endotracheal intubation in surgical patients scheduled for general anesthesia: a prospective blind study. Anesthesia and analgesia. 1995;81(2):254-8.
12. Prakash S, Kumar A, Bhandari S, Mullick P, Singh R, Gogia AR. Difficult laryngoscopy and intubation in the Indian population: An assessment of anatomical and clinical risk factors. Indian journal of anaesthesia. 2013;57(6):569.
13. Cook T. A new practical classification of laryngeal view. Anaesthesia. 2000;55(3):274-9.
14. Juvin P, Lavaut E, Dupont H, Lefevre P, Demetriou M, Dumoulin J-L, et al. Difficult tracheal intubation is more common in obese than in lean patients. Anesthesia & Analgesia. 2003;97(2):595-600.
15. Moon H-Y, Baek CW, Kim J-S, Koo GH, Kim J-Y, Woo Y-C, et al. The causes of difficult tracheal intubation and preoperative assessments in different age groups. Korean journal of anesthesiology. 2013;64(4):308-14.
16. Wilson M, Spiegelhalter D, Robertson J, Lesser P. Predicting difficult intubation. British Journal of Anaesthesia. 1988;61(2):211-6.
17. Vaughan RS. Predicting difficult airways. BJA CEPD Reviews. 2001;1(2):44-7.
18. Khan ZH, Kashfi A, Ebrahimkhani E. A comparison of the upper lip bite test (a simple new technique) with modified Mallampati classification in predicting difficulty in endotracheal intubation: a prospective blinded study. Anesthesia & Analgesia. 2003;96(2):595-9.
19. Jaeschke R, Guyatt GH, Sackett DL, Guyatt G, Bass E, Brill-Edwards P, et al. Users' Guides to

the Medical Literature: III. How to Use an Article About a Diagnostic Test B. What Are the Results and Will They Help Me in Caring for My Patients? Jama. 1994;271(9):703-7.
20. Jones CM, Athanasiou T. Summary receiver operating characteristic curve analysis techniques in the evaluation of diagnostic tests. The Annals of thoracic surgery. 2005;79(1):16-20.
21. Lundstrøm L, Vester-Andersen M, Møller A, Charuluxananan S, L'hermite J, Wetterslev J. Poor prognostic value of the modified Mallampati score: a meta-analysis involving 177 088 patients. British journal of anaesthesia. 2011;107(5):659-67.
22. Lee A, Fan LT, Gin T, Karmakar MK, Kee WDN. A systematic review (meta-analysis) of the accuracy of the Mallampati tests to predict the difficult airway. Anesthesia & Analgesia. 2006;102(6):1867-78.
23. Karkouti K, Rose DK, Ferris LE, Wigglesworth DF, Meisami-Fard T, Lee H. Inter-observer reliability of ten tests used for predicting difficult tracheal intubation. Canadian journal of anaesthesia. 1996;43(6):554-9.